TEACHER EVENT CHECKLIST
X-FLIGHTS (AERONAUTICS)

Date Completed	PRE EVENT REQUIREMENTS
	1. Print out a copy of this entire file (color copy preferred). Please note: this file document is 19 pages long.
	2. Sign Agreement to Participate and E-mail to the Distance Learning Outpost within 3 business days of confirmation.
	3. Have students take Pre-Event Quiz on page 5.
	4. Complete all pre-event activities with the students.
	5. Teacher to E-mail a minimum of 5 student questions to NASA at least 3 business days prior to your event.
	6. Review NASA Event Guidelines.
	DAY OF EVENT ACTIVITIES
	1. The students will be asked to share their results from their pre-work activities with the NASA DLO host.
	2. Bring any appropriate classroom projects or materials to support student presentations.
	POST EVENT REQUIREMENTS
	1. Have students take Post-Event Quiz to demonstrate knowledge of subject.
	2. Teacher(s) and students to fill out event feedback
	3. Distance Learning Outpost will respond to any follow-up questions.
	4. At Teacher's discretion, students can complete extended activities.

Teacher Agreement To Participate
NASA's Distance Learning Outpost

I have reviewed the Learning Module and agree to complete all of the required activities with my students, both prior to, and following, the video teleconferencing event.

Teacher(s) ______________________________

School/Institution ______________________________

Event # ______________________________

Today's Date ______________________________

NASA's Distance Learning Outpost
X-Flights (Aeronautics) 3-12

Instructional Goal:

Students will be able to discuss the design components of an X-Craft (X-38) and the characteristics of structure and function needed for flight

Learning Objectives:

Students will be able to:

1. Describe the history, design and accomplishments for a variety of NASA X-craft.

2. Collect data to demonstrate the basic characteristics of structure and function for controlled flight in the atmosphere.

3. Explore career opportunities and the educational requirements in the field of aeronautical design engineering.

National Education Standards:

Science Standards (NSTA)

Science As Inquiry
Abilities necessary to do scientific inquiry
Understandings about scientific inquiry

Science And Technology
Abilities of technological design
Understanding about science and technology

History And Nature Of Science
Science as a human endeavor

Nature of scientific knowledge
History of science

Mathematics (NCTM)

Measurement
Apply a variety of techniques, tools, and formulas for determining measurements.

Data Analysis, Statistics, and Probability
Pose questions and collect, organize, and represent data to answer those questions.
Interpret data using methods of exploratory data analysis.

Communication
Organize and consolidate their mathematical thinking to communicate with others.

Grade Level:

Grades 3-12

Estimated Time requirements:

- Activity Set #1 30 minutes
- Activity Set #2 60 minutes
- Activity Set #3
  - a. Activity A 60 minutes
  - b. Activity B 50 minutes
- Activity Set #4 25 minutes
- Video Teleconference 50 minutes

STUDENTS WILL BE ASKED TO SHARE THEIR FLIGHT RESULTS AND OBSERVATIONS DURING THE NASA DLO EVENT

Texas Essential Knowledge and Skills (TEKS)

Science
4.A, B **Scientific processes**
Math
3.A **Patterns, relationships, and algebraic thinking**
14.B, C, D **Underlying processes and mathematical information and evaluate predictions and conclusions based on data analysis.**

OVERVIEW
Teams of engineers, mathematicians, and scientists are working together to apply concepts and knowledge to solve new design problems for flight. Discover how designers had solved some of the early problems of flight and look into the future of NASA's air and space X-flight program.

INSTRUCTIONAL STRATEGY

Pre-Event Classroom Component

Activity Set #1

1. Students take Pre-Event Quiz to test their knowledge prior to these lessons about Aeronautics and Experimental aircraft. Keep these quizzes on file to compare to their Post-Event Quiz.

2. Define "flight" and "glide" as a class.

Activity Set #2

Principle of Lift. Have students investigate and develop their principle of lift (based on Bernoulli's Principle of Fluid Dynamics).

Activity Set #3

Activity A **X-Glider.** Introduce X-Glider activity and prepare materials with students to begin this research investigation. Have students test 8 various glider configurations to determine best results for distance and duration. **Students will be asked to share their results during the DLO event.**

Activity B **Glide Ratio.** Introduce Glide Ratio as a concept that mathematically describes the gliding characteristics of an aircraft. Have students determine the glide slope for all gliders flown in X-Glider activity for distance. **Students will be asked to share their data during the DLO event.**

Activity Set #4
1. Student Questions – A Desire To Explore Further
   - Develop at least 5 questions from the class on space stations
   - These questions should go beyond the basic information within the program
   - E-mail your questions at least 3 business days prior to your event with NASA
   - E-mail address is: DLO1@jsc.NASA.gov

2. Prepare the students for their participation in a live, interactive video teleconference with NASA's Distance Learning Outpost.

X-Flight Aeronautics
Pre/Post Event Quiz

1) Identify one historically significant aircraft and one Experimental aircraft. Describe both planes' accomplishments.

2) Describe the main reasons that allow a plane to fly in the Earth's atmosphere. What are the two major factors that allow a plane to obtain lift?

3) What does the mathematical number obtained from a Glide-Slope Ratio tell you about the characteristics of a glider's flight?

4) Identify an experimental spacecraft that can fly in space and in Earth's atmosphere. One that can be used to return astronauts in an emergency situation at a moments notice. What are some of the devices that make this multi-functional spacecraft-aircraft different from previous experimental aircraft?

5) What are some of the activities an aeronautical engineer might do at NASA? What kinds of experiences and education will you need to be able to work in this exciting field of aeronautical design and engineering?

Guided Answers for Pre and Post Quiz:

1. Montgolfier's Hot Air Balloon 1783 Renard's Dirigible 1852 Chanute Glider 1896
Wright Bros. Gliders 1899,1900,1901,1902 Wright Bros. Flyer 1903 von Zeppelin Dirigible 1900
Louis Bleriot, the Bleriot XI 1907 Charles Lindbergh 1927 And others

X-1: Problems of high-speed flight, broke the sound barrier.
X-2: Designed to study heating in flight at three times the speed of sound.
X-3: Designed to break Mack 3, however it did not accomplish this
X-5: Testing variable-angle wings
X-15: Designed to test speed and altitude, 4,500mph and an altitude of 250,000 feet
X-24A: Testing Lifting body design for controlled wingless flight
X-29: Designed to test forward-swept wings
X-33: Planned as an Advanced Technology Demonstrator, vertical take off and airplane landing
X-37: Space Orbital Plane, the next generation of shuttle
X-38: Designed and tested as a Crew Recovery Vehicle for the International Space Station, lifting body design
X-43: Planned as an hypersonic flight vehicle for Mach 5 and reusable space launcher

2. Lift (Daniel Bernoulli's Principle of Fluid Dynamics) and Angle of Attack.
Daniel Bernoulli (1738) is credited with developing the laws that explain how a wing lifts. He discovered a relationship between the pressure and speed of a fluid in motion. "As the velocity of a fluid increases, the pressure decreases." Air moving over the top of a curved wing travels faster than the air moving under a wing's flatter bottom surface. The air that goes over the curved top of the airfoil must travel a greater distance than the air that travels under the bottom while reaching the trailing edge at the same time.
Bernoulli's principle states, "as a fluid's speed increases, the pressure within the fluid decreases." If the pressure above is less, and the pressure below is greater, the airfoil will move upward, towards the lower pressure. It is literally a "suction" on top and a "push" from underneath.
Also important is the angle of the wing as it moves through the air, or as it encounters the relative wind. This is called "Angle of Attack." Lift is increased as the angle of attack is increased. As the angle is increased relative to the wind, the air has to go a further distance over the top of the wing. That means a lower pressure above the wing resulting in greater lift. Even greater "suction" on top and a "push" from underneath. Because there is more wind striking the wing's bottom surface at higher angles of attack, the pressure created on the wing's bottom surface is higher. This is the same feeling you get when you put your hand out of the car window while driving because the direct pressure of the air on the lower hand surface causes it.
Activities with Discrepant Events-Bernoulli's Principle will help students to understand this effect of faster moving air creating lower pressure in relation to slower or still air having higher pressure on an object. Students will conclude their observations with a written summary and illustration that demonstrates their understanding of their "Principle of Lift".

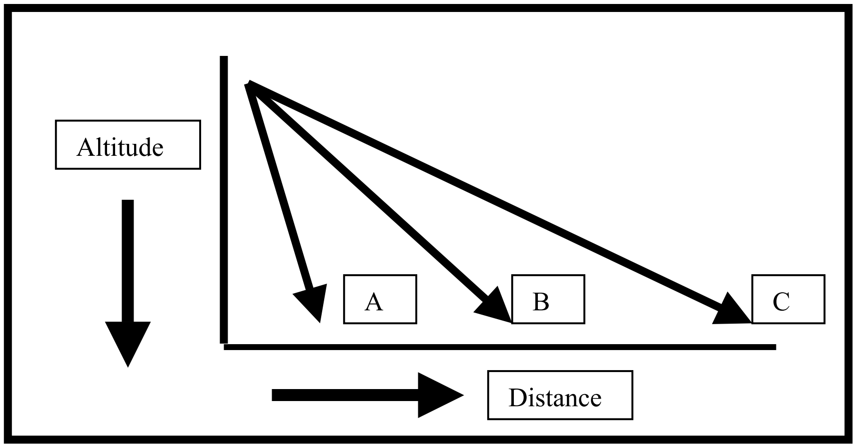
3. The Design Activity “Experimental Gliders” will be used to answer the following two challenges:

1. What design configuration will result the greatest performance for distance?
    a. Measure the height each glider was released from and record
    b. Measure the distance traveled by each glider and record
    c. Divide the distance flown by the height from which the glider was released = glide ratio
    d. Create a data table, chart, or graph that will clearly show:
        i. The distances flown by each configuration – each flight, all flights, or averages
        ii. The glide slope for each configuration – each flight, all flights, or averages
2. What design configuration resulted in the longest performance for time aloft?
    a. Measure the height at which all the gliders will be released from
    b. Measure the time aloft from the instant it’s release to the instant it touches the ground
        i. Use an accurate time piece (stopwatch) to record results
    c. Create a data table, chart, or graph that will clearly show:
        i. The time aloft by each configuration – each flight, all flights, or averages
3. Student Design Engineers are to prepare a short oral-visual presentation to be given during the ‘Aeronautics X-perimental’ NASA Distance Learning event.

4. How well a designed configuration performs (how well it flies or glides through the air) is expressed in the Glide-Slope Ratio.
Glide ratio = ‘Horizontal distance flown’ divided by the ‘Change in altitude’.
For every single unit drop in altitude how many horizontal units did the aircraft travel?
For example:

Horizontal Distance Flown = 50 feet
Change in Altitude = 10 feet
After the division the answer is 5/1. Where for every 1 foot drop in altitude the glider flew 5 feet forward.

In terms of a visual representation a graph might look like this:
“A” would represent a poor Glide Slope of 2/1 (One foot drop in Altitude resulted in 2 feet of Forward Distance)
“B” would represent a better Glide Slope of 5/1 (One foot drop in Altitude resulted in 5 feet of Forward Distance)
“C” would represent the best Glide Slope of 10/1 (One foot drop in Altitude resulted in 10 feet of Forward Distance)



5. Research source: NASA-JSC X-38 homepage
http://hedstest.jsc.nasa.gov/station/assembly/elements/x38/index.html

6.

Aptitudes	**Related Vocational Activities**	**Selected Aerospace Careers**
Mechanical	Equipment Development Aircraft Maintenance Machinery Repair	Aeromechanical Engineer Astronautical Engineer Instrument Repair Technician
Verbal	Speaking and Writing Giving Instructions Persuasive Activities	Flight Instructor Public Relations Director Mission Control-Air Traffic Controller
Scientific	Research and Invention Experimentation Scientific Investigation	Aeronautical Engineer Metallurgist – Astrophysicist Aeromedical Lab Technician
Manipulative	Equipment Operation Machinery Control Instrument Supervision	Aircraft Pilot Flight Engineer Machine Tool Operator
Numerical	Mathematical Calculations Arithmetic Reasoning Computational Activities	Data Processing Engineer Research Mathematician Industrial Accountant
Administrative	Managerial Activities Supervisory Responsibility Secretarial Duties	Research Project Director Management Engineer Stenographer
Social	Service, Advice & Assistance to Individuals and Groups	Personnel Manager Flight Doctor – Nurse Training Director
Artistic	Self-expression through Design Drawing and Creative Skills	Design Engineer Technical Illustrator Scale Model Builder

Activity Set #2

Developing a Principle of Lift
After each demonstration, small groups of students will work the activity until each group can duplicate the same results as originally demonstrated by their teacher.

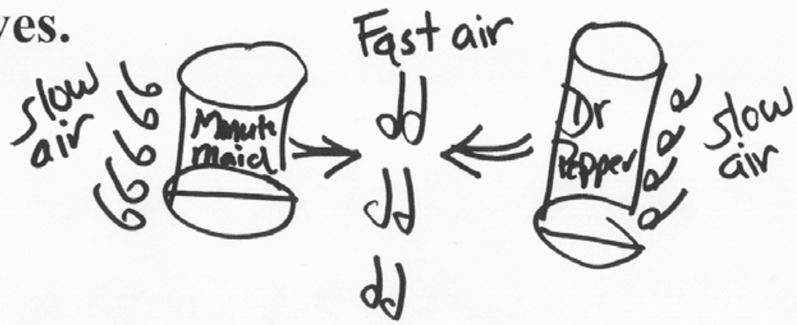
Each small group will write a description (after each demonstration) of what was observed and why they think the objects reacted the way they did when subjected to fast and slow moving air around the objects. They are to include a labeled illustration that indicates the flow of fast and slow moving air around each object (faster moving air equaling low pressure and slower moving air equaling high pressure).

After all the demonstrations have been given and each group has written its observations, explanations, and illustrations a final summary statement (principle) with a selected labeled illustration is to be written. This Principle should be written in a general, broad way to summarize how any object subjected to imbalanced flows of fast (low pressure) and slow (high pressure) moving air will behave.

An example of a Student's Principle of Flight is shown below:

Natalie's Principle

The slow air moves the object toward the fast air and the object moves. The high pressure moves the object toward the low pressure and the object then moves.



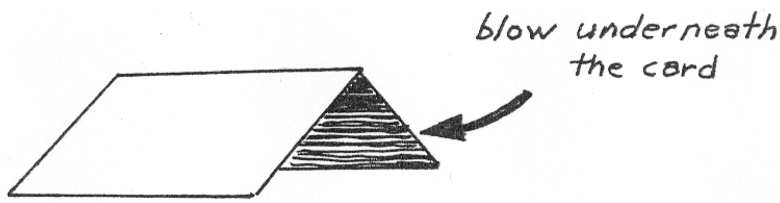
The following Discrepant Event activities will help students understand Bernoulli's Principle by writing their own Principle of Lift.
Each activity has a list of required materials.

Developing and Writing a 'Principle of Lift'

The Collapsible Paper Tent

Materials Required:

1. A pen or pencil and paper
2. 3 x 5 inch note card for each student



Procedure:

1. Distribute the note cards to each student.
2. Fold the cards in the center to form a tent structure.
3. Place the folded tent note card on a desk or table and try to blow the card off the desk or table by blowing underneath it.
4. Predict what will happen before you blow under the folded tent note card.
5. Make a sketch of what was observed. Use thick arrows to indicate stationary (or slower moving) air, thinner arrows for faster moving air, and a line arrow to indicate the motion of the paper strip.

Questions:

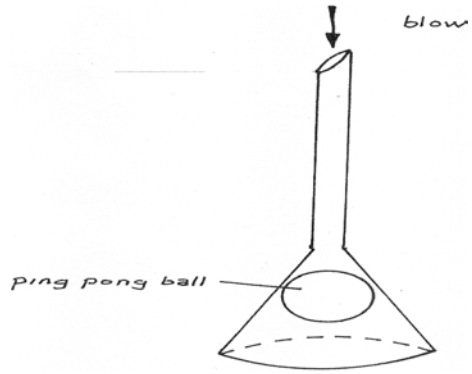
1. What did you observe when blowing underneath the paper tent? Describe the movement of the paper tent.
2. Stationary air exerts equal amounts of pressure on all sides of an object. What is different about the air on top of the paper compared to the air under the paper, when you blew underneath the paper tent?
3. What is different about the flowing air compared to the stationary air?

Explanations:
Stationary air exerts pressure. Flowing air exerts less pressure as compared to stationary air. The faster the flow, the lower the pressure it exerts. By blowing underneath the card, you actually created less pressure underneath the paper, so that the pressure above the paper became larger than below the paper, and this is why the card got pressed down against the table.

The Stubborn Ball and Its Funnel

Materials Required:

1. Pen and Pencil and paper.
2. One long-stem funnel (glass or plastic) per small group of students.
3. One ping-pong ball per small group of students.



Procedure:

1. Place the funnel and ball next to each other on a table.
2. Ask the question: "How can I pick up the ball with the funnel without sucking through the funnel? And I may not touch the ball."
3. Pick up the funnel by the stem, place it over the ball and blow steadily through the stem, lifting the funnel while blowing.
4. Place one hand under the funnel and stop blowing. The ball then drops.
5. Place the ball in the funnel and have a student try to blow the ball out of the funnel. They will not succeed.

Question:

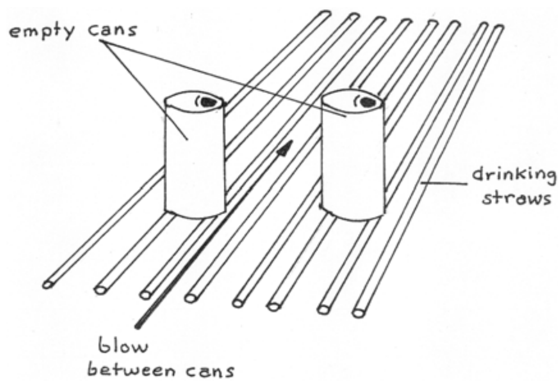
1. How did we pick up the ball with the funnel without sucking through it?
2. What happened when we stopped blowing?
3. Is it possible to blow the ball out of the funnel?
4. Where is the air moving the fastest when we blow through the funnel?
5. What is flowing (faster moving) air creating that stationary air doesn't?
6. What is the difference about the inside compared to the outside of the funnel when we blow through it?

Explanation:

The ball can be picked up from the table with the funnel by blowing through it. When blowing through the funnel we create a lower pressure inside the funnel, especially at the spot where the stem is attached to the conical shape of the funnel. Here the fastest flow of air occurs because the air molecules have suddenly more space to move about. The faster the flow of air, the lower the pressure. This is why the ball is sucked into the funnel by blowing, and for the same reason it is not possible to blow the ball out of the funnel. The harder we blow through the funnel, the lower the pressure gets in the mouth of the funnel.

The Attracting Soda Cans

Materials:
1. Pen or Pencil and Paper.
2. Two empty soda cans per small group.
3. About one dozen straight drinking straws per small group.



Procedure:
1. Spread the straws parallel to each other on the table and spread them out with about 1cm between them.
2. Place the two empty cans upright about 2 cm from each other on the straws and show the students that they can easily move on top of the cans. The straws are used to reduce friction between the tabletop and the cans.
3. Ask the students: “What can possibly happen to the cans if I blow in between them?”
4. Now spread the two cans about 5 cm apart. Will I have to blow softer or harder to get the two cans to come together? Blow harder.
5. Now place the cans about 20 cm apart. Ask the students: “Can I still get the two cans to come together?” Take a deep breath and blow a constant stream of air on the right side of the left can and move your head towards the right, while constantly blowing. The cans will still come together.

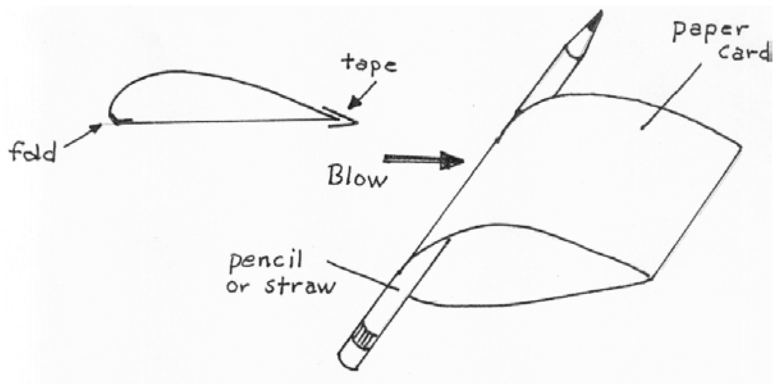
Questions:
1. What made the cans mover closer together?
2. How far apart could the cans be placed and still move together?
3. What does the flowing air create in between the two cans?
4. Was a stronger flow of air necessary to bring the cans that were 20 cm from each other?

Explanation:
Blowing in between the two cans created a flow of air and thus a lower pressure compared to the stationary air on the other side of the cans. It is this lower pressure created on one side of the can that allowed the higher pressure on the opposite side to move the can. In other words creating an imbalance of pressure on the cans. The faster the flow of air, the lower the pressure it exerts.

The Lifting Paper Wing

Materials:

1. Pen or Pencil and Paper.
2. A piece of paper and tape for each small group.
3. A round pencil or straw for each small group.



Procedure:

1. Cut a piece of paper of about 5 X 15 cm and bend and fold into the shape of an airplane wing and tap the ends together.
2. Put a pencil or straw through the wide end of the wing and let the paper wing hand down.
3. Blow over the paper wing and observe its reaction.

Questions:

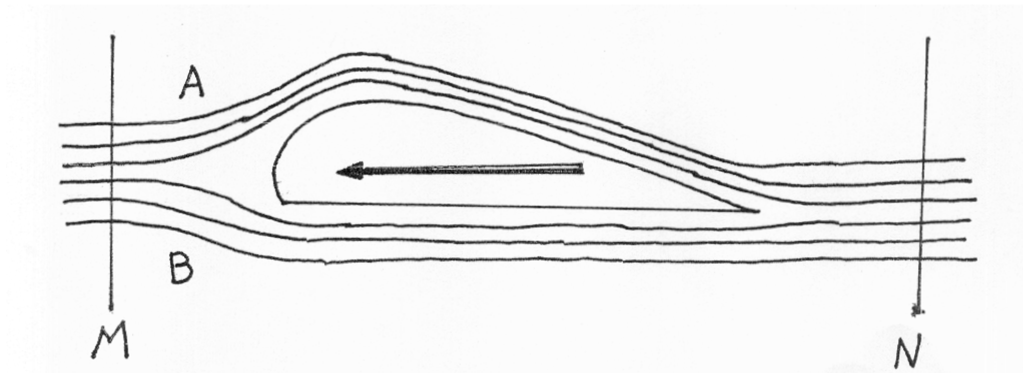
1. Predict how the paper wing will move when you blow over the top of it.
2. Why does the paper wing move up when you blow over it?
3. What would happen if you blew under the paper wing?
4. What happens if you blow over the wing, but invert it with the curved side facing down?
5. What do airplanes do with their wings when they take off of land?
6. What gives airplanes their lift?

Explanation:

Bernoulli's Principle is underlying and causes the lift that the airplane wing provides. The wing is built in such a way that the air over it flows faster than the air under it. It has a grater curvature on the top compared to the bottom side. Therefore there is a greater distance the air molecules need to travel over the top of the wing than on the bottom of the wing.

When we consider air molecules at point 'A' on the top of the wing and air molecules at point 'B' below the wing, and they have to flow from point 'M' to point 'N', it can be see that 'A' has to run faster than 'B' to arrive at point 'N' at the same time.

The wings of an airplane are provided with adjustable flaps that can be extended or retracted. When extended, they increase the curvature of the wing on the upper side and provide a greater lift for take off and landing.



Student Results and Event Presentations

Student Design Engineers are to prepare short oral-visual presentations to be given during the 'Aeronautics X-Xperimental' NASA Distance Learning event. Think 3 minutes each!

Prepare two examples of student written-illustrated 'Principles of Lift' to be shown and discussed between the students and the NASA host.

Activity Set #3

Designing an investigation to determine the best combination of wing-tail-canard configuration to provide:

1. **The greatest flight distance with a standard release method.**
   What design configuration will result the greatest performance for distance?
   a. Measure the height each glider was released from and record
   b. Measure the distance traveled by each glider and record
   c. Divide the distance flown by the height from which the glider was released = glide ratio
   d. Create a data table, chart, or graph that will clearly show:
      i. The distances flown by each configuration – each flight, all flights, or averages
      ii. The glide slope for each configuration – each flight, all flights, or averages
2. **The longest flight time with a standard release method**
   What design configuration resulted in the longest performance for time aloft?
   a. Measure the height at which all the gliders will be released from.
   b. Measure the time aloft from the instant it's release to the instant it touches the ground
      i. Use an accurate time piece (stopwatch) to record results
   c. Create a data table, chart, or graph that will clearly show:
      ii. The time aloft by each configuration – each flight, all flights, or averages

X-Gliders: Exploring Flight Research with Experimental Gliders
The glider templates with this activity allow educators and students to build and experiment with eight basic wing-tail-canard configurations.
http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/X.Gliders/X-Gliders.pdf

Student Results and Event Presentations

Student Design Engineers are to prepare short oral-visual presentations to be given during the 'Aeronautics X-Xperimental' NASA Distance Learning event. Think 3 minutes each!

Visually show the final X-Glider configurations for:
a. Best distance flight
b. Best time aloft flight

Describe the investigative process, data collection process, and analysis used to determine 'best configuration'.

Calculating the Glide Ratios for each winning configuration.

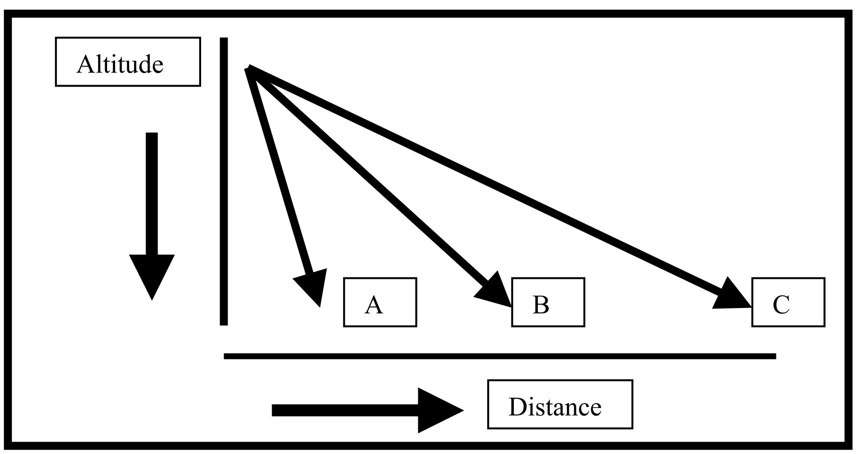
How well a X-Glider designed configuration performs (how well it flies or glides through the air) is expressed in a Glide-Slope Ratio, or Glide Ratio.

Glide ratio = 'Horizontal distance flown' divided by the 'Change in altitude'.
How many horizontal units did the aircraft travel for every single foot drop in altitude?
For example:
Forward ***Distance*** = 50 feet
Change in ***Altitude*** = 10 feet
After the division the GLIDE RATIO is 5/1.
Where for every 5 feet forward the craft drops 1 foot.

In terms of a visual representation a graph might look like this:
"A" would represent a poor Glide Slope of 2/1
For every 2 feet forward the craft drops 1 foot.

"B" would represent a better Glide Slope of 5/1
For every 5 feet forward the craft drops 1 foot.

"C" would represent the best Glide Slope of 10/1
For every 10 feet forward the craft drops 1 foot.



Student Results and Event Presentations

Student Design Engineers are to prepare short oral-visual presentations to be given during the 'Aeronautics X-perimental' NASA Distance Learning event. Think 3 minutes each!

Speak with understanding and describe what a Glide Ratio means, provide the Glide Ratio data, and provide a visual representation of some of the data for comparison.

Student Results and Event Presentations

Student Design Engineers are to prepare short oral-visual presentations to be given during the 'Aeronautics X-perimental' NASA Distance Learning event. Think 3 minutes each!

Students should be prepared to discuss the results of their FoilSim investigations in terms of:

a. Understanding the relationship between wing shape and lift.
b. Effect of changing variables on wing shape.

NASA Event Guidelines

Review the following points with your students prior to the event:

1. A video teleconference is a two-way event. Students and NASA presenters can see and hear one another.
2. Students are representing their school; they should be on their best behavior.
3. Students should be prepared to give brief presentations, ask questions and respond to the NASA presenters.
4. A Teacher(s) or other site facilitator should moderate student questions and answers.
5. Students should speak into the microphone in a loud, clear voice.

Get Ready, Be Ready, and have fun with your

Distance Learning Event with NASA!

Post-Event Teacher – Student Evaluation

1. **We need your help and support!** Choose the appropriate Form below. It usually takes teachers and students **less than 10 minutes** to complete. We welcome any input that you have at the following sites:
    - Teacher Feedback Form:

      https://ehb2.gsfc.nasa.gov/edcats/centers/distance_learning.html
    - Student 4-12 Feedback Form:

      https://ehb2.gsfc.nasa.gov/edcats/centers/dlo_412_student.html
    - Technical Contact Feedback Form:

      https://ehb2.gsfc.nasa.gov/edcats/centers/jsc_dlo_tech_contact.html
    - Parent/Chaperone Feedback Form:

      https://ehb2.gsfc.nasa.gov/edcats/centers/distance_learning_parent.html

2. Students and Teachers are **welcome to e-mail the Distance Learning Outpost** with any follow-up questions from the event at: mailto:DLO1@jsc.nasa.gov

3. **Please send** us any photos, video, web page link, newspapers articles, etc. of your event. We will be glad to post them on our web page!

Extended Activities for X-FLIGHTS

Welcome to the Aircraft Design Workshop Try your hand at the design of a 200 passenger airliner, flying from Washington D.C. to the destination of your choice. You may modify the airplanes wings, tails, engine, fuselage, and cruise settings by clicking on the small pictures above. Then click on the image in the upper right to analyze and display your design.

http://connect.larc.nasa.gov/activities/adw/welcome.html

FoilSim was developed at the NASA Glenn Research Center in an effort to foster hands-on, inquiry-based learning in science and math. FoilSim is interactive simulation software that determines the airflow around various shapes of airfoils. Students change the position and shape of the wing by moving slider controls that vary the parameters of airspeed, altitude, angle of attack, thickness and curvature of the airfoil, and size of the wing area. The software displays plots of pressure or airspeed above and below the airfoil surface. A probe monitors air conditions (speed and pressure) at a particular point on or close to the surface of the airfoil. The software calculates the lift of the airfoils, allowing students to learn the factors that influence lift. The latest version of FoilSim (Version 1.4b) includes a model of the Martian atmosphere for lift comparisons.
http://www.grc.nasa.gov/WWW/K-12/FoilSim/index.html